IRRADIATED FOOD: CONSUMER CONCERNS AND WILLINGNESS TO PURCHASE

A Thesis by

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Presented in partial fulfilment of
the requirements for the degree of
MASTER OF AGRICULTURAL ECONOMICS

Massey University, Palmerston North
New Zealand

March 1994

Abstract

A national survey of households in New Zealand employed a systematic random sampling technique and conducted to determine the consumers' concern and willingness to purchase irradiated food. The characterization of the consumers based on willingness to pay and level of concern was analyzed using two separate econometric models. The first method used the dichotomous choice logit model for willingness to pay whilst the second model involving four point scaled level of concern employed the ordered logit model. Both models determined the demographic effects on willingness and concern.

The consumers level of concern for food irradiation was lower than the consumers' concern for pesticide and chemical residues in food and other food safety issues. The results also suggest that the likelihood of buying irradiated food was dependent on diet, sex, urbanisation, knowledge of food irradiation and consumer beliefs about the radioactivity, wholesomeness and health effects of irradiated food at different levels of significance. Concern was found to be directly effecting willingness to purchase and this concern could influence the consumer's buying behaviour. Concern level, on the other hand, was highly influenced by sex and the consumers knowledge of food irradiation. Higher level of concern was evident among those who were not willing to buy irradiated food. However, a significant number of the surveyed respondents were undecided about buying or not buying irradiated food.

The demographic information of this study is useful to the marketing of fresh produce in New Zealand, specially those who anticipate direct marketing activity of irradiated food. The results are also useful in designing policies related to irradiation of food products in New Zealand.

Acknowledgements

The completion of this thesis would not have been possible without the contribution of many people who gave their time generously.

I wish to acknowledge Professor William C. Bailey for his advice and encouragement for the completion of this study. Professor Bob Townsley is thanked for his invaluable assistance in setting the econometric models. I owe a debt of gratitude to the financial support from the Massey University Agricultural Research Foundation (MUARF) that enabled me to conduct the survey of the study.

I am grateful to my first supervisor, Dr. Rodolfo M. Nayga Jr. for his inspiring guidance and without whom this work would have never been initiated. Dr. Bing Soo of the Food Technology Department and Professor Errol Hewitt of the Department of Plant Science are thanked for providing useful literatures during the early stage of the work and for their critiques on the questionnaire.

The friendly *kababayang Filipinos* who helped me with the conduct of the survey are appreciated for their untiring efforts that expedited the distribution of the questionnaires. Ruth Wilson-Salt is thanked for her help in the conduct of the survey. The entire faculty and staff at the Department of Agricultural Economics and Business are appreciated for their support that facilitated the survey. I am grateful to Dedi Budiman Hakim for his help in struggling with SAS problems.

My sincere gratitude to my friend, Tony Banks for his support and encouragement in the last two years. Rani Govindasamy and Rohit Mehta are likewise thanked for the comraderie. Finally, I would not have finished this thesis without the fervent support of my *tatay, inay,* my brothers and my sisters.

Dennis M. Bautista

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Irradiated Food: Consumer Concerns and Willingness to Purchase

Chapter 1

Introduction

There would be meat stored in great piles in rooms; and the water from leaky roofs would drip over it, and thousands of rats would race over it. It was too dark in these storage places to see well, but a man could run his hands over these piles of meat and sweep off handfuls of the dried dung of rats.

Upton Sinclair's *The Jungle*

1.1 Food Safety and Public Concern

Public concern about the safety and healthfulness of the food supply grew markedly during the 1980s. Over the past three years, concerns towards food safety have practically delved into public consciousness caused significantly by concerns over pesticide residues and other chemicals. The Alar scare in the US (Senauer, Asp and Kinsey 1991) is one of the most recent proof. Continuing debates over issues such as fungicide residues on produce, pesticide residues on imported foods, traces of dioxin in milk containers and the potential cancer-fighting value of foods like oat bran or cruciform vegetables, use of growth promotants in animals and plants suggest that these types of concerns aside from food irradiation will grow in prominence in the coming years.

Numerous government, academic, interest groups, and media reports questioning the adequacy of food safety regulatory system formed the basis for this increase in concern. Relatively little research on the complex economic aspects of food safety and nutrition issues had been conducted up to the mid-1980s.

Consideration of the effectiveness of alternative regulatory programs and the impact of use of food safety and healthfulness as a marketing tool on food consumption patterns and competition in food markets comprise the supply side of the economics of food safety. On the demand side are consumers' perceptions of the risks associated with particular food products, influence of demographic characteristics on consumers' processing of risk information and subsequent changes in food demand behaviour, and the monetary value consumers might place on changes in the risk profiles of products. Associated with current food consumption patterns are the economic benefits and costs which serve as major determinants of demand for improved safety and dietary change through government regulation (Caswell, 1991). Increasing concerns over pesticides and other food safety issues has led to development of alternative technologies that could address health concerns.

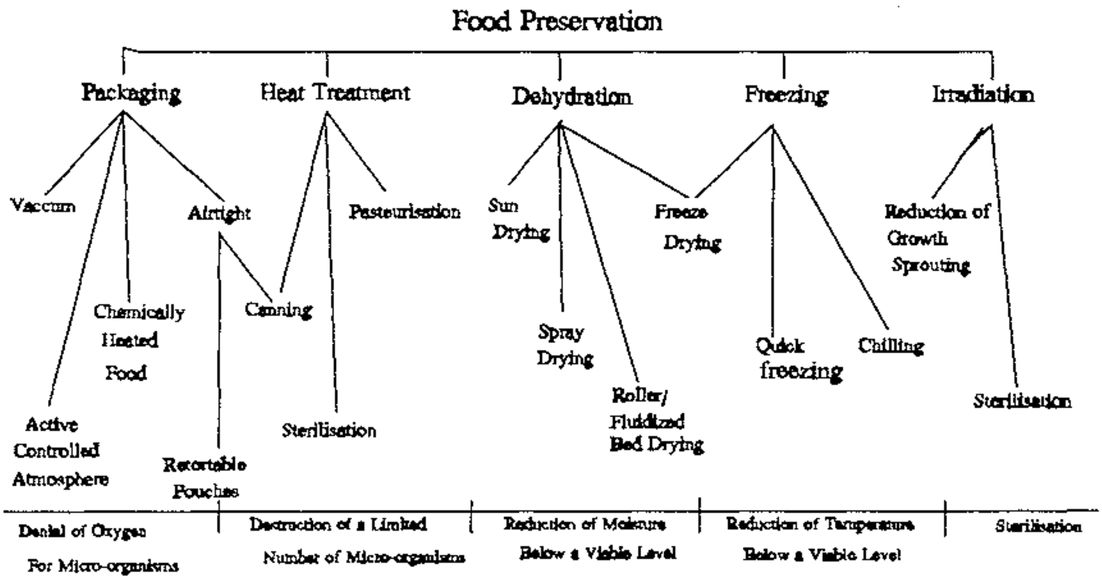
1.2 Food Irradiation

Food irradiation is a controversial process. Irradiation comes from the Latin word *radius* meaning ray is, to most consumers, the emission of harmful radioactivity. It is often associated to frightening images of destruction formed from reports of nuclear disasters in Japan, the United States (US) and the former United Soviet Socialist Republic (USSR). It is a subject which has an unprecedented extent of polarised opinions on its value and safety.

Food products may be exposed by gamma radiation from the radioactive sources cobalt-60 (^{60}Co) or caesium-137 (^{137}Cs), or through a machine source such as electron accelerator that emits electron beams and or x-rays. The dose of radiation measured in kilogray (kGy) a food product absorbs depends upon the length of time it is exposed to the radiation source (Jones 1992). It is a fact that most preservation techniques usually affect the nutritional value, flavour or texture of a food. Food preservation methods involve processes with a common aim to create a hostile environment for the micro-organisms in food without unduly affecting its chemical composition and physical structure. It is a preservation technique that falls under the physical category of food preservation. Physical method, as differentiated from chemical method of food preservation, includes freezing, heat treatment, dehydration, vacuum and modified atmosphere packaging (Figure 1.01). Irradiation is actively lethal to bacteria and does not simply provide a hostile environment. This makes food irradiation differentiated from other physical food preservation techniques. It has less discernible effect upon food quality than any other preservation techniques but the process is inappropriate an technique for cleaning up food otherwise unsafe for human consumption (Robins 1991).

Induced chemical changes in irradiated foods has led to early legislations in the US classifying irradiation as an additive. Only recently has irradiation been classified as a process.

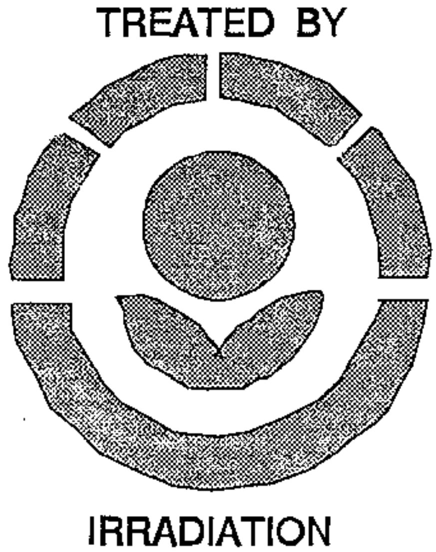
Figure 1.01 Physical Methods of Food Preservation



Source: Robins (1991)

First used in the Netherlands, the international irradiation symbol (Figure 1.02) together with the statement *treated by irradiation* or *treated with irradiation* is recognised internationally for food products sold in retail packages (Terry and Tabor 1990). The radura logo has an outer ring broken into five parts representing the rays coming from the energy source or the central solid circle. The two petals represent the food (Blackholly and Thomas 1989).

Figure 1.02 International Symbol for Irradiated Food



Source: **Blackholly and Thomas (1989)**

1.2.1 An Historical Development

The discovery of x-ray resulted in the recognition of ionizing radiation. Schwartz established the practical use of food irradiation in 1921 when he obtained a US patent on the use of x-rays to kill the parasite *Trichinella spiralis* in meat which is a cause of worm infection in humans. In 1930, Wust obtained a French patent for preservation of food by irradiation (Robins 1991).

The intent for modern research began in 1943 by the US Army's conduct of investigations at the Massachusetts Institute of Technology (Mc Ewan in Food Irradiation 1987). Ten years after England started to work on food irradiation in 1948, Russia became the first country to grant clearance for human consumption of irradiated potatoes. In the mid 1950s the US Army Quartermasters Corps sponsored research as part of President Eisenhower's 'Atoms for Peace' policy (Robins 1991; Jones 1992). The process became technically feasible only in the late 1950's and early 1960's.

The period of 1960 to 1970 witnessed the widespread researches on the wholesomeness and technical aspects of food irradiation. In 1970, the International Food Irradiation Project (IFIP) was launched by 19 countries exploring the combination of food irradiation with other preservatives (Diehl 1990). IFIP was replaced by the International Consultative Group for Food Irradiation (ICGFI) in 1984 by Food and Agricultural Organisation (FAO), the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO).

The JECFI or Joint FAO, IAEA and WHO Expert Committees on the Wholesomeness of Irradiated Food experimented on ten kilogray dose and less and found neither toxicological hazard nor microbiological problems on the irradiated food. The Codex Alementarius Commission adopted the *General Standard for Irradiated Food* and the *Recommended International Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Food* (Diehl 1990).

The United States Food and Drug Administration (USFDA) approved a one kilogray treatment of raw pork to kill trichinae in 1985. Later in 1986, the US FDA permitted use of irradiation to inhibit growth and maturation of fresh fruit and to disinfest food adulterated with insects. Labelling was under strict regulation. In 1990, three kilogray dose was approved for poultry by the US FDA (Jones 1992).

The WHO declared food irradiation as *a powerful tool against preventable food loss and food borne illness*. Just before the explosion of the Chernobyl plant in the former USSR in 1986, the ACINF or the Advisory Committee on Irradiation of the British government also declared that *irradiation of any commodity up to an overall average dose of 10 kilogray presents no toxicological hazard; hence, toxicological testing of food so treated is no longer required* (Diehl 1990).

There has been worldwide interests coupled with controversies on food irradiation in the past. Seemingly, that interest has not trickled down and controversies have not gone unchecked by consumers worldwide. There are over 50 food products approved for irradiation in 36 countries (Jones 1992).

In New Zealand, Regulation 264 of the Food Regulations 1984 stated that:

> *no person shall sell any food that has been treated by ionising radiation unless the treatment is for the time being approved by the Minister*

The Minister of Health has given only one approval for the irradiation of one tonne of spices in 1985 treated to an average of absorbed dose of eight kilogray. The Food Standards Committee proposed that Ministerial approval warrants proper labelling (Food Irradiation 1987; Food Irradiation and Industrial Radiation Processing in New Zealand 1988). New Zealand has had a commercial non-food irradiator since 1966 at Upper Hut, Wellington. This plant was one of the first in the world dedicated to the sterilisation of medical products such as bandages, dressings and the like (Roberts and Sutton 1985).

The use of food irradiation in the food industry overseas is growing steadily, but it is likely to be several years before New Zealand industry makes extensive use of the process. So much interest on food irradiation has been devoted by New Zealand during the early 1980s. A national symposium was held at Massey

University, Palmerston North in 1984. The symposium was followed by the 56th Congress of the Australia and New Zealand Association for the Advancement of Science and a session devoted to food irradiation was included (Food Irradiation 1987; Food Irradiation and Industrial Radiation Processing in New Zealand 1988).

In February 1988, a discussion document titled *Food Irradiation and Industrial Radiation Processing in New Zealand* was made available to the public by the Ministry for the Environment. Three working groups looked into the irradiation uses in New Zealand, technical aspects associated with food irradiation and implications of food irradiation in New Zealand for local consumption, for export and the desirability of irradiating imported food (Food Irradiation 1987).

The proposal by a major company to build a large-scale irradiation plant in Auckland in 1984 gave rise to considerable public concern and an unprecedented number of town planning objections. Public concerns triggered by the proposal to build the large-scale plant at Mangere in the city of Manukau led to the preparation of the above document.

Some of the major concerns brought out by the proposal were related to the need for consumer understanding of food processing options relating to safety, wholesomeness and taste; consideration of the effectiveness and acceptability of the current quarantine process; projection of the New Zealand image overseas, both as a food exporter and as a tourist venue; and the need for information and effective labelling to provide for consumer choice.

There is a wide range of opinion. The Department of Health concluded that provided there are controls on the process, there are food that can be safely irradiated. The Food Standards Committee has prepared a proposal on the labelling of irradiated food, should irradiation treatment be permitted.

New Zealand legislation governing radiation safety is embodied in the *Radiation Protection Act 1965* and the *Radiation Protection Regulations 1982*. A requirement of the Act is that nobody may operate an irradiation facility unless a license under the Act has been issued for the purpose, or the operation is carried out on the instructions or under the supervision of the licensee. The licensee is personally responsible for ensuring the safe operation of the plant. The National Radiation Laboratory administers the Act and Regulations under delegated authority from the Director-General of Health and is the license issuing authority (Food Irradiation 1987).

The research for food irradiation became more intense and the interest on it became much more widespread when ethylene dibromide (EDB) was found to have health implications and banned in the US. To date, no chemical replacement for EDB has been found. Food irradiation may establish itself as new method of food preservation in the coming years, but application of the technology and its progress may be slow because of the need to reassure consumers that irradiated food are safe.

1.2.2 Role of Food Irradiation

In terms of time, money and effort spent to study a food preservation technique, irradiation probably has been more thoroughly studied than other techniques such as drying, canning, freezing and the use of chemicals. More research has been focused on the effects of irradiation on food than has been directed at any other form of food processing. This research has spanned more than 40 years and has been carried out in many countries. Irradiation below one kGy may provide a safe alternative to toxic gases or chemicals as a method of disinfestation, decontamination or sprout inhibition. There is a powerful incentive to use irradiation as an alternative to pesticides and disinfectants which can leave noxious residues. Fumigants, sterilising gas, and ethylene oxide which are facing strong consumer concerns over its residues may be phased out. Food irradiation is a useful method when used as a combination treatments for food preservation.

A few of the known benefits of food irradiation are extension of shelf life by eliminating food spoilage organisms, reduction in the use of post harvest chemicals for preservation and pest control, elimination of insects and parasites and production of sterile products not requiring refrigeration, improved sanitary level of food which could lower health care costs due to reduced microorganisms and fewer food-borne illnesses (Roberts 1985), safe transfer of produce from insect quarantine areas, and replacement of less safe chemical fumigants (Diehl 1990). Furthermore, the following uses of food irradiation may be added to the above: inhibit sprouting of vegetables; delay ripening of fruits; kill insect pests in fruits, grains or spices and elimination of parasites; greater convenience and better quality food; and reduce food poisoning bacteria on some meats and sea food products (Diehl 1990; Pszczola 1990; Urbain 1989). Table 1.01 shows the dose rates used for the main uses of irradiation. Radiation treatments may be divided into the low dose methods (ten kilograys and above) which progressively reduce microbial populations. Complete sterility is not achieved below 50 kilograys, and this level is not customarily used in foodstuffs.

Table 1.01 Dose Rates Recommended in Food Irradiation

Process	Dose Range (kilogray)
Inhibition Sprouting	0.05 - 0.15
Delaying Ripening	0.20 - 0.50
Disinfestation	0.20 - 1.00
Shelf Life Extension	0.50 - 5.00
Elimination of Pathogens (non sporing)	3.00 - 10.0
Bacterial Sterilisation	50.00

Source: Robins (1991)

Food irradiation is perceived to consume less energy than freezing and refrigeration. This may be a big advantage in the light of the dwindling energy supplies. The safety of irradiated food generally overshadows any worries about its nutritional quality. Irradiation brought about fewer adverse chemical changes than did traditional heat processing of food (Jones 1992).

1.2.3 Arguments Against Food Irradiation

The chemical changes brought about in food by irradiation are perhaps the most contentious issue surrounding the introduction and acceptance of the technique. It is often claimed that the exact nature of the chemical changes induced are not well understood and it is possible that harmful substances are products of unknown but potential toxicity. It is possible that such effects will be subtle and only manifest themselves in the long term (Robins 1991). Wholesomeness reflected in nutritional quality is affected through destruction of some vitamins and major nutrient content (Robins 1991).

Food irradiation has a very minor role as an operative method of food preservation at the moment. There is uncertainty about the safety of food irradiated at high enough doses to prevent all microbiological spoilage (Robins 1991). Consumers may find difficulty choosing between fresh and irradiated food since there is no way to check whether food has been irradiated except for its label. In addition, reirradiation may cause an alarm to other consumers. The effect of irradiation on packaging materials used in irradiated food is another concern (Jones 1992). Moreover, the following are classified as adverse effects of food irradiation unique chemical changes; loss of vitamins and impairment of nutritional value; off-flavours and aromas; limited range of applicability; necessity for use of additives to offset undesirable effects; adverse health effects in animals and humans fed on irradiated food; potential for contamination of the environment by food irradiation facilities; potential hazards of transporting Co-60 and Cs-137 from its manufacturers to an irradiation facility; and formation of new chemical substances or radiolytic products (Diehl 1990; Jones 1992; Robins 1991). The business sector may be hesitant due to unpredictability of the potential of food irradiation brought about by technical problems, high start-up costs and consumer resistance (Jones 1992). Table 1.02 summarises the advantages and disadvantages of food irradiation as viewed by consumers (Robins 1991).

1.2.4 Current Status of Food Irradiation

Food irradiation using ionizing energy offers to revolutionise the food industry. Irradiation is currently permitted in over 30 countries. In Western Europe, the Netherlands is the major user. France, Denmark, Belgium, Luxembourg, Spain and Italy permit irradiation. Ireland, Greece and Portugal on the other hand has no rules either permitting or forbidding the use. In December of 1989, the Food Safety Bill was being put through the House of Lords and proposals were put forward to adopt food irradiation in the United Kingdom.

In 1985, Belgium, the Netherlands and Japan are the only countries allowing food irradiation of selected commodities. The number of countries allowing irradiation has increased to 24 by 1989. These countries allow irradiation of food and/or food ingredients for commercial use (Jukes 1991). Some of the countries authorising food irradiation with clearances varying tremendously from permission for irradiation for experiments, for test marketing, for export only, for provisional periods to unconditional authorization include the United States of America, Japan, Argentina, Bangladesh, Brazil, Canada, Chile, China, India, Israel, Mexico, Norway, Philippines, South Africa, Thailand, Uruguay and various Eastern European countries (Robins 1991).

Table 1.02 Advantages and Disadvantages of Food Irradiation

For	Against
* Kills most of the bacteria in treated food, including salmonella, listeria and campylobacter.	* Bacterial toxins formed pre-irradiation will not be destroyed and could still cause food poisoning.
* Can replace potentially carcinogenic chemical fumigation to preserve food and destroy insect infestation of herbs and spices.	* Botulism will not be eliminated.
	* Viruses and aflatoxin will not be destroyed.
* Can increase the shelf life of many food, including vegetables, shellfish and poultry.	* Vitamin loss during processing occurs in addition to the normal storage and cooking losses. Extended shelf life will mean greater losses.
* Reduces sprouting in stored potatoes and onions.	* Vitamin E and B1 are seriously affected during irradiation.
* Can delay ripening in some fruit and possibly introduce greater choice over a wider season.	* Some food, such as chicken, may suffer a loss of fatty acids - this can occur in mild heat treatment processes such as pasteurisation.
* Could provide extra safety for pre-prepared meals.	* Old, dirty or previously unacceptably contaminated food could be disguised.
* Could improve the taste and texture of certain food.	* Despite claims to the contrary, pre-harvest pesticides will continue to be necessary and could become harmful in combination with irradiation.
	* With no test to determine whether or not food have been irradiated, accurate documentation with irradiation will be relied on.
	* Sterilisation by irradiation does not address the problems of unhygienic food handling and processing, which cause some of the contamination.

Source: Robins (1991)

In the United States and Canada, changes in federal regulations are paving the way for the introduction of irradiated food into the marketplace. However, many consumers are wary of the term irradiation and will not be easily convinced to purchase irradiated food. The US FDA has cleared the irradiation of pork and fresh fruit and vegetables to one kilogray, some products to ten kilogray and dried herbs and spices, seed, teas and seasonings to 30 kilogray. The US FDA has given its approval to irradiate poultry to control salmonella (Jukes 1991).

In Brazil, studies on disinfestation by irradiation involve all the important pests of stored grain and grain products. Cooperative work has begun to determine the commercial feasibility of grain irradiation. Disinfestation of both fresh and dried fruits, especially if the produce is intended for export, is also held to be of great economic importance. In the Brazilian environment, the use of food irradiation is considered most likely to be used for grain preservation, possibly as an alternative to the fumigation of nuts. China has invested heavily in the development of food irradiation and five demonstration plants. The Shanghai irradiation centre, opened in January 1986 can process up to 35,000 tonnes of vegetables a year or about 45 percent of the city's annual supply.

Irradiated food cannot be recognised by sight, smell, taste or feel. The only sure way for consumers to know if a food has been irradiated is for the product to carry a label that clearly announces the treatments in words, a symbol or both. Irradiated food need not be labelled on health grounds. No one method has yet been found that is suitable for wide and routine application in order to identify whether food have been irradiated. Techniques offering most promise in the detection of irradiated food are the measurement of electron spin resonance to identify irradiated bone and fat, the determination of conductivity differences for the identification of potatoes, the detection of malonaldehyde to identify irradiated starch and the measurement of certain radiolytic hydrocarbons in fats and fatty meat.

A number of expert committees or groups such as the Joint Expert Committee on Food Irradiation, UK Advisory Committee on Irradiated and Novel Food, US FDA, a Danish Working Group and the Science Council of Canada reflect the majority of opinion that there are food that can be safely irradiated. The governments of more than 30 countries appear to be satisfied with the safety of at least some irradiated food.

In December 1988, the FAO, WHO, IAEA and the International Trade Centre of the UN Conference on Trade and Development/General Agreement on Tariffs and Trade (GATT) organised a conference to review the methods for the trade of irradiated food. The UK government decided to permit food irradiation. The proposed Regulations laid on December 1990 before the UK Parliament came into operation on the first of January 1991. The legislation in UK has occurred except for Northern Ireland where separate legislation was being prepared (Jukes 1991).

While the UK is enthusiastic over its introduction, many countries are steadfastly against it, and those countries that favour it are in a definite minority. Several member states of the European Community have already permitted the use of food irradiation whilst in the others it is still banned. The European Parliament opposed the 1989 proposal for the legislation of food irradiation. The Commission who drafted the proposal revised the rejected proposal and made minor changes to the new proposal which now awaits the agreement of a common position in the European Parliament (Jukes 1991). It is also evident that the impact of food irradiation upon the international trade of food will be slight until some compromise is reached between exporting countries which permit it and importing countries which ban the irradiation of incoming food. The resolution of this conflict must be based upon a thorough evaluation of the usefulness of the technique and the safety of irradiated food (Robins 1991).